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Research Note—

A Self-Propelled, Constant-Speed Spray Vaccinator for Commercial Layer Chickens

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SUMMARY. Vaccination of commercial layer chickens is labor intensive and often results in poor rates of seroconversion, which, in turn, generally correlate with decreased flock uniformity and performance. Attempts to improve the vaccination process include numerous variations of individual shop-built vaccinators in use by the layer sector of the poultry industry. Each of these vaccinators has limitations that contribute to poor vaccinations. Major problems include the nonuniform speed of the applicator system and pressure fluctuations at the spray nozzles, which contribute to sporadic dispersion of the vaccine as the vaccinator is pushed or carried past the cages. A battery-powered, self-propelled, constant-speed vaccinator was designed and constructed that operates with constant nozzle pressure. In field use, this vaccinator has resulted in both labor savings (reduction of manpower from five to one to vaccinate 75,000 chickens) and time savings (from 45 min to 7.5 min/poultry house) as well as improved vaccination results (higher positive seroconversion rates) against the poultry pathogen *Mycoplasma gallisepticum* (MG), a bacterium associated with losses of 15.7 eggs/hen over a 45-wk laying period in MG-infected layers as compared with layers maintained free from infection with MG.

RESUMEN. *Nota de Investigación*—Dispositivo de vacunación por aerosol de propulsión autónoma y velocidad constante para ser empleado en explotaciones de ponedoras comerciales.

La vacunación de ponedoras comerciales es una labor intensiva que resulta con frecuencia en índices pobres de conversión serológica, la cual a su vez, se correlaciona generalmente con una disminución de la uniformidad y el desempeño del lote. Diferentes intentos para mejorar los procesos de vacunación incluyen numerosas variaciones de dispositivos de vacunación construidos actualmente y en uso por el sector avícola de ponedoras comerciales. Cada uno de estos dispositivos posee limitantes que contribuyen a una pobre vacunación. Los problemas principales incluyen la velocidad desuniforme del sistema de aplicación y fluctuaciones en la presión de las boquillas de aspersión que contribuyen a una dispersión esporádica de la vacuna a medida que el dispositivo de vacunación es desplazado a través de las jaulas. Se diseño y construyó un dispositivo de vacunación activado mediante batería, de propulsión autónoma y velocidad constante que opera con una presión constante a nivel de las boquillas. En el campo, este dispositivo de vacunación ha logrado una reducción de los costos de operación (reducción en mano de obra de cinco a una persona para vacunar 75,000 ponedoras comerciales), ahorro de tiempo (de 45 minutos a 7.5 minutos por galpón) y mejores resultados de vacunación (incremento en los índices positivos de conversión serológica) contra el patógeno aviar *Mycoplasma gallisepticum* (MG), bacteria asociada con pérdidas de 15.7 huevos por ponedora en un período de 45 semanas en ponedoras comerciales infectadas en comparación con ponedoras comerciales libres de la infección con MG.

Key words: chicken, layers, *Mycoplasma*, poultry, vaccination, vaccinator

Abbreviations: MG = *Mycoplasma gallisepticum*

Vaccination, particularly for respiratory diseases, is a necessary component for success in intensive commercial poultry production. Currently, vaccine delivery in commercial chicken houses occurs via three predominant administration methods: drinking water, eyedrop, or spray. Each of these methods utilizes water as the means of vaccine reconstitution and as the delivery medium (1). While successful vaccine administration with each of the foregoing delivery methods is predicated on the vaccine, diluent, environment and dosage (4), each delivery system has its own requirements for successful administration.

Improper vaccine application is the most common reason vaccines and vaccine programs fail. Producing uniform and consistent seroconversion with vaccines intended for eyedrop delivery is dependent on proper and consistent individual bird eyedrop administration. Vaccine administration by bird watering systems relies on shutoff and removal of water from birds for two to three hours followed by re-supply with water containing the vaccine. Spray administration tends to be the most troublesome of the delivery systems. Although spray administration often results in non-uniform and inconsistent seroconversion as a result of some birds being sprayed profusely while others receive little or no vaccine, it is desirable for ease and cost of application and is the preferred method for inoculating the respiratory system (1). Within the commercial table egg sector of the poultry industry, spray application is considered to be the most effective delivery system for the administration of most *Mycoplasma gallisepticum* (MG) vaccines (6), and has become increasingly popular for the respiratory vaccines, Newcastle disease virus, and infectious bronchitis virus (1). Inconsistent or non-uniform administration can result in ''rolling reaction'' within a flock which in turn can result in longer recovery with the overall impact of decreased flock performance.

To control production losses, estimated to be 15.7 eggs/hen over a 45-wk laying cycle in MG-infected hens as compared with hens

Fig. 1. The CPJ battery-powered, self propelled, constant speed, poultry spray vaccinator in a commercial layer chicken house.

maintained free from MG infection (3), three MG vaccines have been approved for restricted use in layer chickens (6). Administration of the three currently available live MG vaccines to commercial table egg poultry is currently advocated at less than 10 wk of age by each of the three MG vaccine manufacturers (Intervet, Inc., Millsboro, DE; Merial Select, Gainesville, GA; and Schering-Plough Animal Health, Omaha, NE), and is frequently performed at 8 wk (J. Self, Cal-Maine Foods, Inc., personal communication, Jackson, MS, June 20, 2003). *Mycoplasma gallisepticum* serum plate agglutination (SPA) tests are typically conducted six weeks post-inoculation on 20 randomly selected pullets (D. Thornton, MS Board of Animal Health, personal communication, June 17, 2003). By some developing criteria, successful vaccine administration results when 50% or greater of the vaccinates are SPA positive 6 weeks post-inoculation while SPA test results of less than 50% positives generally warrant immediate revaccination (J. Self, Cal-Maine Foods, Inc., personal communication, June 20, 2003).

Numerous spray vaccinators, the majority of which are in-house shop-built, are currently used in the commercial table egg industry to administer MG vaccines. However, none of these vaccinators are self-propelled (J. Self, Cal-Maine Foods, Inc., personal communication, June 28, 2004). Uniformity and consistency in delivery of spray vaccines for cage-housed animals could be improved through development of a self-propelled, constant speed device having a pump reservoir system capable of spraying vaccine through a series of height-adjustable nozzles, operating with minimum noise, and delivering a uniform dose. The purpose/objective of this report is to describe a new caged-layer chicken-vaccinating device, termed the CPJ (acronym for the first letter of the last name of contributing engineering technicians) vaccinator.

MATERIALS AND METHODS

Description of battery-operated, self-propelled, constant speed, poultry spray vaccinator. A 159 kg steel cart (130 × 58

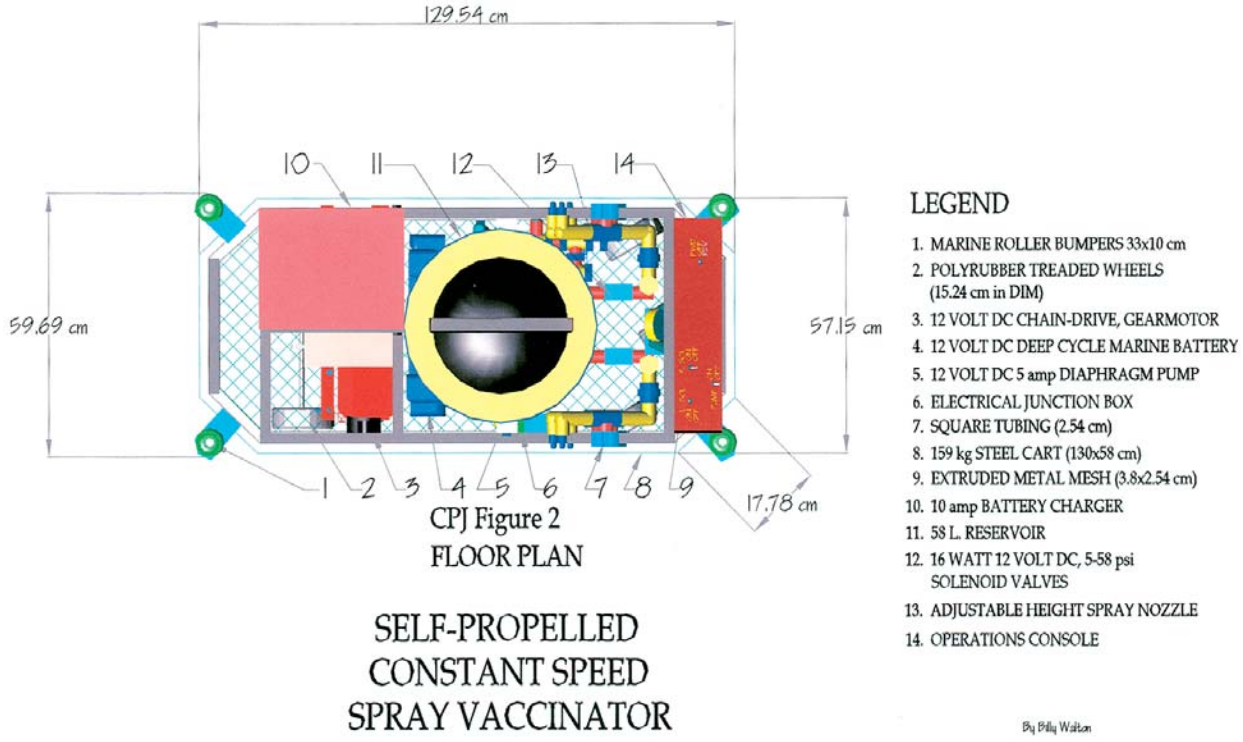

Fig. 2. Plan view of the CPJ battery-powered, self propelled, constant speed, poultry spray vaccinator.

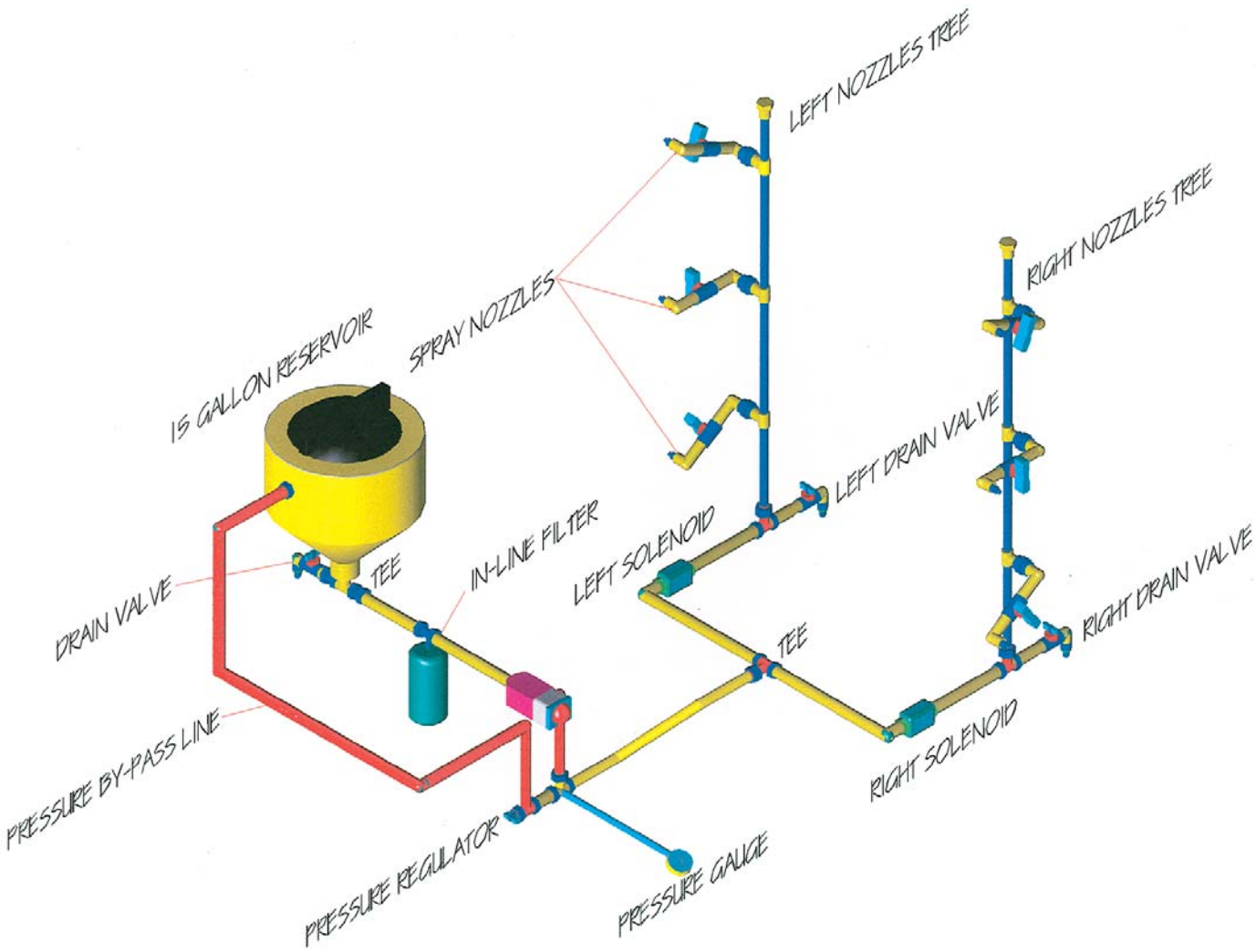

Fig. 3. Plumbing schematic of the CPJ battery-powered, self propelled, constant speed, poultry spray vaccinator.

cm) was constructed using 5 × 5 cm angle steel and 5 × 0.6 cm flat steel for flooring and wheel support. Extruded metal mesh (3.8 × 2.54 cm) was used for flooring. Square tubing (2.54 cm) was used to construct a spray nozzle frame. The cart was equipped with a Grainger Industrial Supply, Stock #1Z833 (Jackson, MS), 0.20 hp, 18.5 amp, 12 volt DC chain-drive, gearmotor having a torque of 74 in/lb and a gear ratio of 11.0:1 bolted to a hinged tensioner mount. To the motor shaft a Grainger Industrial Supply, Stock #6L808 6.3 cm diameter, 19-toothed, drive sprocket having a 0.8972 cm pitch was affixed and on the 57 × 1.9 cm pull (front) axle a Grainger Industrial Supply, Stock #6L805 5.69 cm diameter, 18-toothed sprocket with a 0.85504 cm pitch was mounted. The drive and axle sprockets were connected by a 74.3 cm, number 35 roller (bicycle) chain. Grainger Industrial Supply, Stock #4W871 polyrubber treaded/polyolefin hubbed wheels, 15.24 cm in diameter and 3.8 cm wide, were on the front axle which was supported with two 2.25 cm flange bearings. The two rear, outer wheels consist of Grainger Industrial Supply, Stock #4W871 plate, swivel polyrubber treaded/polyolefin hubbed casters, 15.24 cm in diameter, 3.8 cm wide. A Grainger Industrial Supply, Stock #1G264 5 cm wide rear, center-mounted swivel caster was mounted to provide 3 mm clearance for the rear axle mounted wheels. Marine roller bumpers 33 × 10 cm were bolted to each cart corner. The spray vaccinator propels itself at a constant speed of 3.6 mph. At this speed it takes 1 minute and 45 seconds to traverse a 167.6 m long pullet house aisle. The vaccinator (Figures 1 and 2) is capable of both forward and reverse motion.

Figure 3 shows a schematic of the sprayer pump and plumbing system. A Norwesco, Cat. #10849 AN (Albertville, AL) 58 L plastic reservoir was connected via 1.9 cm PVC fittings to a Spraying Systems, Tee Jet Low Profile Line Strainer Cat. #AA122-PP-3/4 (Wheaton, IL) in-line filter. The filter was connected via flexible, high-pressure, 1.9 cm diameter hose to a Grainger Industrial Supply, Stock #4UN19 Shur Flo Stock #2088-343-135 12 volt DC, 5 amp diaphragm pump which delivers 11.36 L/min at 45 psi mounted to the cart floor. Out of the pump a 1.9 cm diameter PVC "T" was installed. At the "T," a Spraying Systems, Tee Jet Pressure Relief Valve Cat. #23120A-PP-3/4 pressure regulator maintains set pressure through recirculation to the reservoir via 0.25 cm flexible tubing. The opposite end of the pump was connected with flexible, 1.9 cm diameter high-pressure hose to two Motion Industries, Alcon Cat. #VACD3DC (Columbus, MS) 16 watt, 12 volt DC, 5-85 psi solenoid valves. Plastic tubing (0.95 cm diameter) from the solenoids courses to 1.9 cm diameter, vertical PVC pipes located at the rear on either side of the cart. Three adjustable height nozzle assemblies placed on either side of the cart are capable of providing direct spray application from 35.6 to 167.4 cm in height. Spray nozzles are equipped with Intervet Inc., Model 806-09, K-15 coarse spray tips. In addition to the in-line filter, a 10 cm diameter, 1 mm pore-size stainless steel mesh screen was placed in the bottom of the 58 L plastic reservoir and similar screens were placed in each nozzle assembly.

Figure 4 shows a schematic of the sprayer's electrical system. A 12 volt DC deep cycle marine battery (115 amp hours, 160 amp reserve capacity) mounted at the bottom of the cart provides power to the

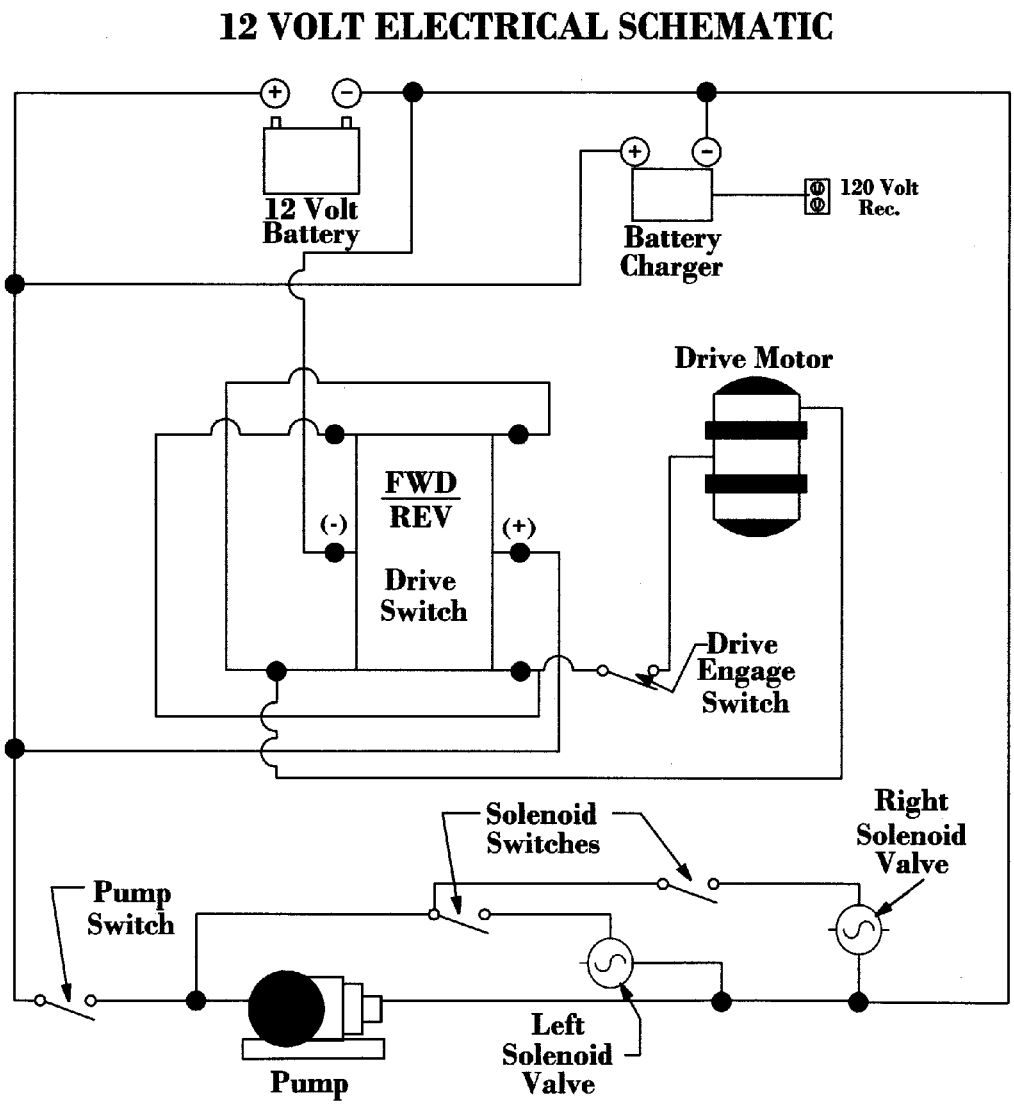

Fig. 4. Electrical schematic of the CPJ battery-powered, self propelled, constant speed, poultry spray vaccinator.

pump, the right and left solenoid switches, and the drive train. The vaccinator can operate for 7 hours and 45 minutes under a full load. A 10 amp battery charger was mounted at the top, front of the cart. The operations console was mounted at the rear (end opposite the cart drive train) and consists of toggle switches for forward/reverse, independent on/off switches for the right/left solenoids, on/off pump switch, thumb-operated cart power engage switch, and a pressure gauge.

***Mycoplasma gallisepticum* vaccination.** Over an 11 month period, pullets were sprayed at each of two farms with live MG vaccine (F-VAX-MG®, Schering-Plough, Animal Health) at nine weeks of age. A total of 38 houses, each containing 75,000 pullets, were vaccinated using either the prototype CPJ vaccinator (20 houses) or a "shop-built," push-cart vaccinator (18 houses). The "shop-built" vaccinator was comprised of a cart with a plastic reservoir and was equipped with a CO_2 canister and pressure regulator which was joined to the vaccine reservoir via plastic tubing. Vaccine was then forced through plastic tubing and ultimately through coarse spray tips (K-15 Model 806-09, Intervet, Inc.®) onto the pullets. All vaccines were reconstituted with 34.7 L of sterile, distilled water and administered at 40 psi. The MG vaccines used on both farms originated from only two serial lots and both lots were represented on both farms. Droplet size of the spray was not determined. Fans at both farms were cut off immediately before vaccination began and remained off until 20 minutes following vaccination completion.

***Mycoplasma gallisepticum* serology testing.** Six weeks post-inoculation, two chickens were removed from cages representing each of the four corners of the laying house and an additional 12 chickens were removed from cages located at the middle of the house, in addition to representing aisles on both house sides as well as the center aisles. Approximately 3 mL of blood was removed and sera were obtained from each sample. Serum plate agglutination tests were conducted as described by Kleven (5).

Statistical analysis. The postinoculation MG SPA results were analyzed with the GLM procedure of SAS (7). Prior to analysis, the MG+ ratios were transformed by the $\arcsin\sqrt{\text{proportion}}$. After the analysis, the resulting transformed mean values were then converted back to their respective proportions (8). The significance difference in the inoculation results was considered at $P \leq 0.05$.

RESULTS AND DISCUSSION

One relationship of misting or vaccinating nozzles dictates that reduced pressure results in increased droplet size (9). Although droplet size was not measured, the physics of droplet size relative to the constant pressure and more consistent speed capabilities of the CPJ vaccinator would suggest a more uniform dosing of each bird that was sprayed. Field use of the vaccinator has resulted in an 80%

Table 1. *Mycoplasma gallisepticum* serum plate agglutination test results from commercial layer chickens vaccinated with live F strain *Mycoplasma gallisepticum* (F-Vax MG®) using the CPJ battery-powered, self-propelled, constant-speed poultry spray vaccinator *vs.* non–self-propelled, backpack poultry spray vaccinator.

Self-propelled vaccinator[A]			Non–self-propelled vaccinator		
Date	# Sera	Ratio (%) MG+	Date	# Sera	Ratio (%) MG+
2/7/2003	20	20/20 (100)	2/5/2003	10	10/10 (100)
2/14/2003	20	19/20 (95)	2/5/2003	10	10/10 (100)
2/19/2003	20	10/20 (50)	5/28/2003	12	12/12 (100)
3/5/2003	15	11/15 (73)	7/23/2003	20	17/20 (85)
3/6/2003	20	19/20 (95)	7/30/2003	19	3/19 (16)
4/3/2003	20	16/20 (80)	8/20/2003	30	13/30 (43)
4/4/2003	20	20/20 (100)	8/27/2003	20	10/20 (50)
5/8/2003	20	15/20 (75)	9/4/2003	9	8/9 (89)
5/30/2003	20	16/20 (80)	9/4/2003	9	2/9 (22)
6/13/2003	20	20/20 (100)	9/24/2003	15	3/15 (20)
7/9/2003	20	18/20 (90)	10/14/2003	20	20/20 (100)
8/7/2003	19	6/19 (32)	10/22/2003	30	4/30 (13)
8/8/2003	19	19/19 (100)	12/4/2003	12	4/12 (33)
8/27/2003	19	19/19 (100)	12/4/2003	20	5/20 (75)
9/18/2003	20	20/20 (100)	12/10/2003	30	27/30 (90)
10/16/2003	20	20/20 (100)	12/11/2003	20	7/20 (35)
10/22/2003	19	15/19 (79)	12/11/2003	18	18/18 (100)
10/29/2003	20	12/20 (60)	12/23/2003	20	11/20 (55)
11/13/2003	19	14/19 (74)			
12/10/2003	18	18/18 (100)			
		$\bar{x} = 90.63^{a}$			$\bar{x} = 70.57^{b}$

[A]Values with different superscripted lowercase letters are significantly different ($P \leq 0.05$).

reduction in labor (from 5 men to 1 man) and an 84% reduction in time required to vaccinate each 75,000-bird house (from 47½ minutes to approximately 7½ minutes). These savings more than offset the estimated $2,850 cost of the vaccinator.

Six-week postinoculation MG SPA test results have demonstrated a significant increase in positives of 90.6% with use of the CPJ vaccinator in twenty 75,000-bird flocks birds as compared with positives of 70.6% derived from a similar layer facility during which time chickens were vaccinated utilizing the ''shop-built'' push-cart, vaccinator (Table 1).

Field use of the prototype CPJ vaccinator has demonstrated extremely quiet operation with concomitantly less disturbance among the birds as compared to the use of either gasoline-powered, backpack sprayers or push-cart, generator-powered vaccinators. Also, the capacity of the deep cycle marine battery used is such that the reserve amps more than compensate for the 7½ minute interval required to vaccinate the typical 75,000 bird chicken house. Although to date the CPJ vaccinator has only been used to administer MG vaccine to layer pullets, it is anticipated that the vaccinator will be used to administer Newcastle disease and infectious bronchitis booster vaccinations to laying hens. Impact of the CPJ vaccinator on egg and egg shell quality parameters such as eggshell breaking strength and blood/meat spot incidence will be evaluated as previously described (3).

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